UAr Implementation C.Kendziora

Introduction

The second phase of DarkSide 50 involves removing the normal Argon used in the detector and refilling the detector using low background Under Ground Argon (UAr). An additional heated getter gas purification system has been added to DS50 for the final purification of the UAr gas as it is transferred into the detector. There are several steps that need to be accomplished in order to prepare DS50 for the use of UAr and prevent any accidental loss of this precious gas:

1) Leak test of entire recovery and getter system.
2) Test recovery system (condensing).
3) Test compressing the gas from recovery system in to empty cylinders.
4) Getter System Test
5) Recovering DS50 high purity Ar and compressing it into cylinders for storage
6) System Maintenance (Changing vacuum pumps and gauges)
7) Cleaning System (evacuation and backfilling with N2)
8) Filling DS50 with UAr

Important note: Maximum Allowable Working Pressure of sub systems:
High pressure piping MAWP: 3000 psig
Low pressure piping MAWP: 100 psig
DS-50 recovery system MAWP: 1.29 barg (19.2 psig)

New System Configuration

Fig 1 Illustrates a temporary system setup that will be used for steps 1 through 5.

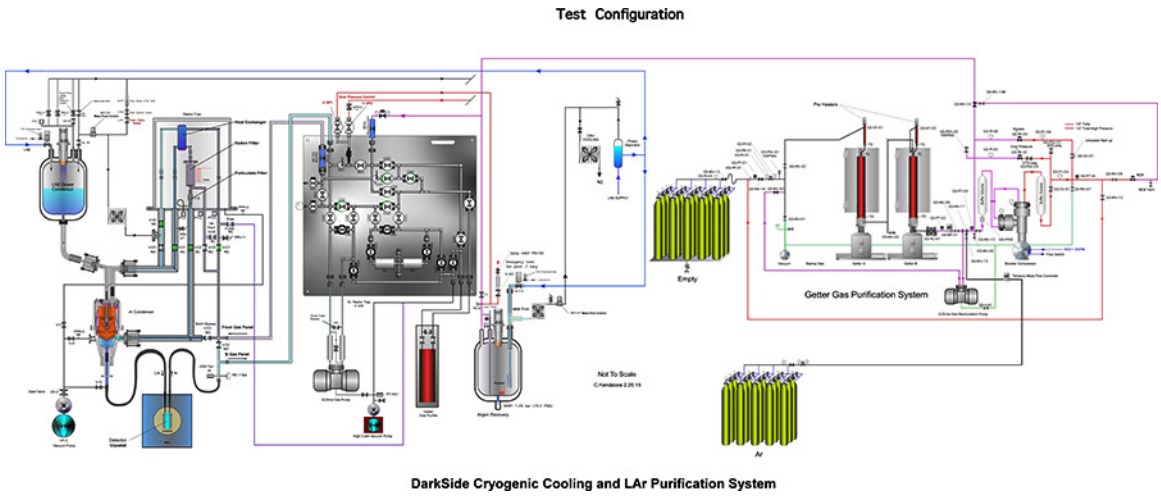

Fig 1 (System Configuration)

Leak Test

The getter and recovery systems must be evacuated and leak checked using a helium mass spectrometer with a sensitivity greater than 1X10-9. Any detectable leak is not acceptable. *Completed*

Recovery System

There will be a set of tests that will be performed to understand and verify the performance of the Recovery System. This includes a Condensing Capacity Test of each of the condensers, a Power Failure Test using the LN2 condenser as an alternative condenser, Emergency Pressure Limit Test and a compressor test that will compress the argon into high pressure cylinders.

Pressure Safety Limit Test

The pressure of 1.29 barg is the Maximum Working Pressure (structural limit) of the recovery dewar. The recovery system has a pressure limit rupture disk that is set for 1.13 bar. The rupture disk is the final safety device in case all else fails. In addition to the rupture disk there is a pneumatic valve with a set point of .7 barg to open and .6 to close. This valve will open and close venting off small quantities of gas keeping the pressure below the rupture disk limit. During normal operation the cryo coolers will keep the pressure in the recovery system below these pressure limits. *Completed*

Condensing Performance Tests

Normal argon will be fed into the system through MV-06 using a temporary mass flow controller. The flow of argon will bypass the getter and compressor circuits and go straight to the recovery system. At the recovery system the argon will be condense and liquid will be accumulated. The LN2 condenser will be tested first to understand it's performance. Because of it's unique custom design, little is known about it's performance. Second, the AL 300 cryo cooler performance will be verified.

Power Failure Test

Knowing that the entire inventory of UAr may someday be located in the recovery system, it's important that we test for a power failure condition. In this condition the LN2 condenser should go into operation. This condition needs to be tested and verified that the recovery system can maintain it's self even during a complete power blackout. *50% Completed*

Compressor Test

Once a significant amount of argon has been condensed in the recovery system, the process will be reversed. A small heater (Omega KHLV-105/10) is now located at the bottom of the dewar of the recovery system. The heater will be used to boil off some liquid that will feed the compressor with a gas. The compressor will compress the gas into the empty set of cylinders. It's important that the heater power not boil off the gas at a rate that exceeds .9 barg in the dewar. There is a software interlock that will turn off the heater in the event the .9 barg is reached.

Preparation for DS50 Ultra Pure Argon Recovery

After all of Recovery System commissioning tests have been completed the Normal Argon will need to be vented out of the high pressure cylinders and the entire system including the high pressure cylinders must be evacuated to remove any standard argon left in the system. The normal argon cylinders of argon can be removed and valve GS-MV-13 can be closed.

Recovery of DS50 Ultra Pure Argon

The high purity argon that is presently in DS50 will be removed by condensing the argon in the recovery system using the recovery system cryo cooler. It will then be compressed into evacuated cylinders by the high pressure compressor. The goal would be to condense the gas in the recovery system while compressing the gas in the cylinders.

The transfer of DS50 ultra high purity gas will take place as illustrated in fig 2.

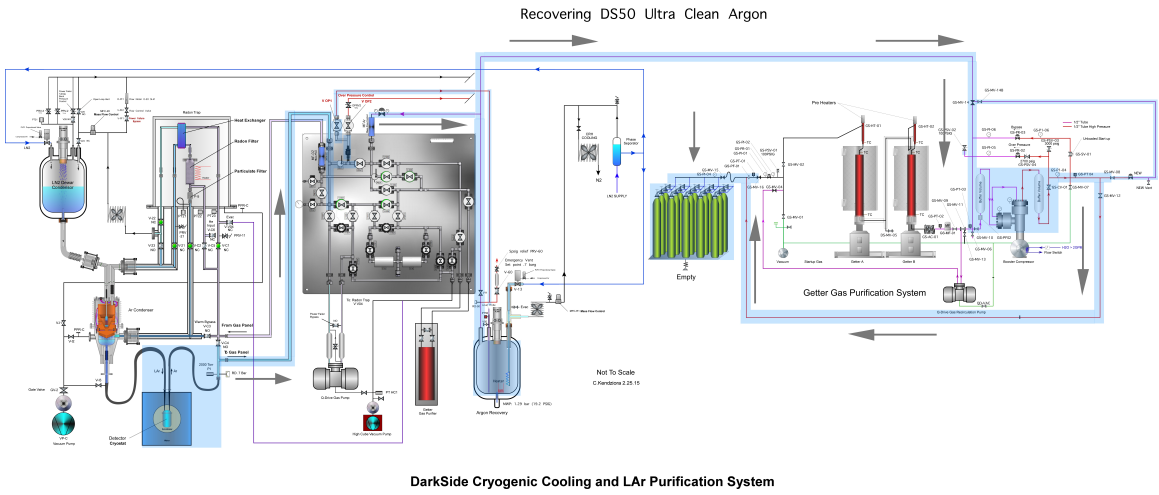

Fig 2 (DS50 Ultra Pure Argon Recovery)

The “Empty” rack which was temporarily used during the recovery system tests will need to be located in the position where the Normal Argon rack was removed from and completely evacuated.

Near the end of the transfer of the gas when there is almost no liquid argon in DS50 the cooling system will be put back in a normal operating condition and a power failure test will be performed on the control system to verify that it can successfully reboot and load the operating control software correctly without any issues. Performing this test with very little argon left in the detector minimizes the potential loss of any of DS50 high purity argon but yet allows us to see what will happen during a total power failure in a normal operating condition.

Once the power failure test of the control system has been completed the rest of the ultra clean argon will be recovered into the recovery system and then compressed into the empty high pressure cylinders for storage. There will be a scale located under the rack of these cylinders that will be used to weigh the content of the gas from DS50. The amount of weight measured will be the quantity of UAr needed to fill DS50 as it was.

Getter Controls Test

Once the leak check of the getters has been completed. A closed loop circulation test using the Q dive should be performed using DS ultra pure argon as illustrated in Fig 6. This test will be to verify that all the instrumentation and controls work correctly using a small amount of DS ultra pure argon

System Maintenance

After the detector has been warmed up and empty of Ultra Pure Argon, the insulating vacuum system should be turned off and the system maintenance should be performed. This incorporates changing the fore pump of the main turbo in the cooling tower and the bad vacuum readouts in the vacuum system. This also includes changing all of the plastic fittings and tubing. With the entire system warm provides the opportunity for all the frozen gas impurities to be pumped out.

System Cleaning

The entire cooling tower system including the detector needs to be evacuated and backfilled (X3) with N2 to displace any Argon that may contain Ar39. All trapped volumes of argon in the system need to be identified, evacuated and purged. The radon trap should be isolated while still cold and evacuated separately from the rest using the Hi Cube Turbo Pump avoiding the possibility of putting contaminates that may have accumulated in the radon trap back into the system. There is concern that the TPB will evaporate and there is some worry about the PMT electrical solder joints failing if a full vacuum is achieved in the detector. Therefor the DS50 detector should only be evacuated to .1 bar and then immediately backfilled with N2 to one atmosphere three times. It should be left with N2 at atmosphere and isolated by closing valves VC-2, VC-3 VC-4 and MF2 until the UAr is ready to be brought online. The insulating vacuum will be maintained and the detector will be left below freezing point of water.

Filling DS50 with UAr

UAr is a rare precious gas that requires great care in handling it to prevent any possible losses or contamination.

The filling of DS50 with UAr needs to be in the final filling configuration as illustrated in Fig 3. The cylinders that contain the DS50 ultra pure argon needs to be removed from the system. The manifold for connecting all of the cylinders of UAr need to be put in place and leak checked. The entire system up to and including the detector needs to be evacuated and purged with N2 as previously mentioned. The getter system must be fully operational before any UAr is added to the system by adding a small amount of UAr to the getter circulation circuit, then recirculating the

gas in a closed loop using the Q drive pump until the getters are at 400 degrees C for at least 4 hours. Once the getters are up to 400 C for four hours, the UAr gas should be allowed to flow through the getters into the rest of the system up to the MF2. The detector should then be evacuated to a full vacuum of .01 mbar and then immediately backfilled with UAr through MF2. The cooling tower needs to be brought on line and the full inventory of UAr be condensed into the detector. The empty cylinders of UAr will be permanently left in place in the event the UAr needs to be transferred back into the original cylinder rack for storage long term.

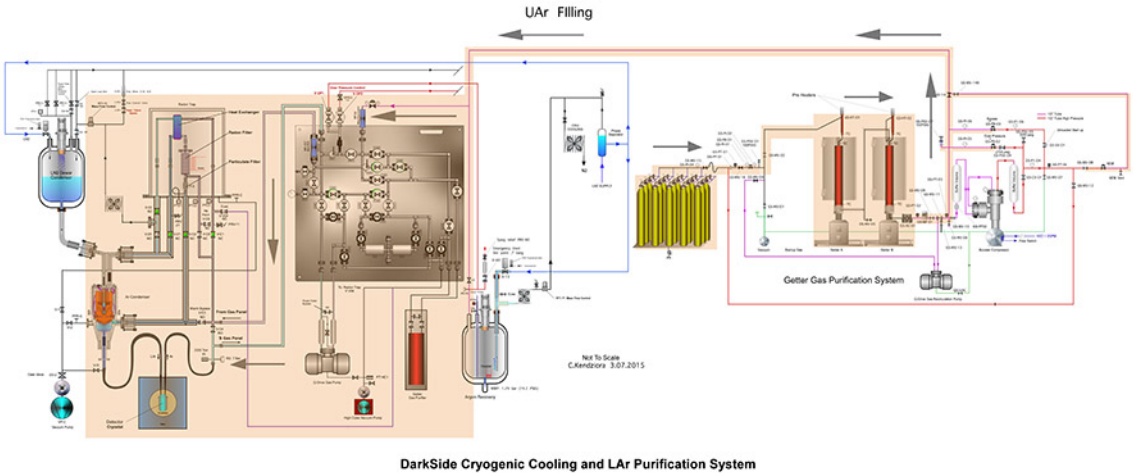

Fig 3 (Filling Configuration)